BROOKS' PERIODIC COMET, 1889 V = 1896 *c.*

By William J. Hussey.

The rediscovery of this interesting periodic comet, by M. Javelle at the Nice Observatory on the twentieth of June, renders this an appropriate time to pass in review its last appearance, and to give some account of the investigations which have been made relating to its past history.

The comet was first discovered on the sixth of July, 1889, by Mr. William R. Brooks, of Geneva, New York. It was described as a faint telescopic comet, somewhat elongated, having a stellar nucleus and a short, broad tail. At first it seemed of very little importance and for a time, partly owing to bad weather, it was very sadly neglected. The first elements of its orbit were computed by Dr. Chandler. From its direct motion and the smallness of the inclination of the plane of its orbit, he at once stated that it was almost certain to prove a comet of short period. Such is the case, its period being a little more than seven years.

Interest in the comet was awakened by Professor Barnard's discovery of August 1, 1889. While he was examining the region about the comet, he found two objects which proved to be companion comets. Each of these companions had a very small nucleus and a short, faint tail, "presenting a perfect miniature of the larger one, which was well developed, with a small nucleus, and a fan-shaped tail." These comets were called *B* and *C*, in the order of their distances from the principal comet, which was denoted by *A*. The comets *B* and *C* both preceded *A* in space, *B* at an angular distance of from 64″ to 74″, and *C* from 265″ to 357″, during the time they were under observation.

On the night of August 4th, he discovered two more very faint companions, denoted by *D* and *E*. *E* was not seen with certainty except on this occasion, and at no other time was *D* bright enough for measurement.

The observations of *B* cover twenty-three nights from its discovery to September 5th. It had then become very large and diffuse, and it was not seen after that date. The observations of *C* extend from its discovery to November 25th, after which time it was not seen. During the time it was visible, it varied considerably in appearance and brightness. In August

its brightness increased and it became more definite in form. About the middle of September it began to fade, at first gradually and then more rapidly. The companion *B* was seen at several other observatories, and *C* was observed at fifteen other places. *D* and *E* were seen only with the thirty-six-inch equatorial of the LICK Observatory.

The principal comet *A* remained visible long after its companions had disappeared. Professor BARNARD continued to observe it with the thirty-six-inch telescope until January 12, 1891, or 555 days after its discovery. No other comet has been observed through so long a period at one apparition.

This comet is chiefly interesting on account of its past history. This was first investigated by Dr. CHANDLER, after the comet had been under observation for only a few months, and while the elements of its orbit were still somewhat uncertain, and afterwards by Dr. POOR, whose later researches are based upon Dr. BAUSCHINGER'S excellent definitive elements.

Dr. CHANDLER pointed out that the comet's aphelion is near the orbit of *Jupiter*, and that its orbital velocity there is nearly the same as that of the planet. In consequence of this, when both happen to be in that region, they remain near each other for several months. This happened in 1886, when the comet approached nearer to *Jupiter* than the outer satellites, and it may be as near or nearer than the Fifth Satellite, and when for more than a hundred days its distance from the planet was less than a tenth of the distance of the Earth from the Sun. By this close approach to *Jupiter*, the comet experienced violent perturbations. Its orbit was completely changed. The line of apsides was reversed and turned through twenty degrees; the line of nodes was reversed and turned through nineteen degrees; the inclination was changed fourteen degrees. It now moves in a small ellipse with a period of a little more than seven years (7.07 years); it formerly moved in a much larger ellipse with a period very nearly four and a half times as long (31.38 years according to Dr. POOR). Its present aphelion has almost the same position as its former perihelion.

These changes are shown in Figure 1, by Dr. POOR. (Johns Hopkins University Circulars, May, 1894). The orbits of the Earth, *Jupiter* and *Saturn* are represented by circles and the present orbit of the comet by the small ellipse. The full-line portion of this ellipse indicates that part of the orbit described by the comet

while it was under observation from July 6, 1889, to January 12, 1891. The *exact* position of the orbit previous to the encounter with *Jupiter* in 1886 is unknown; the observations of the last apparition, extensive though they were, were not sufficient to settle this point definitively. The observations of the present

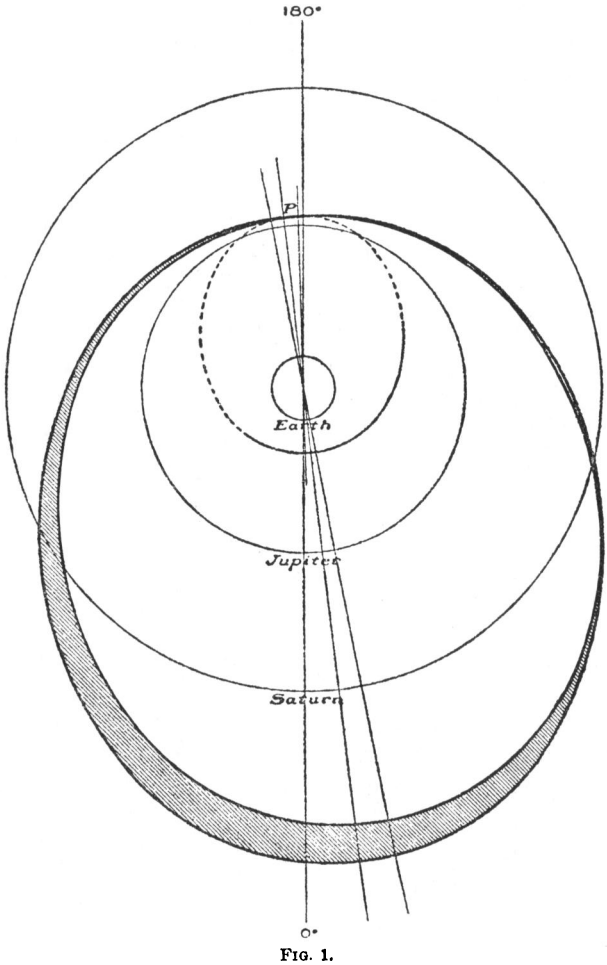

FIG. 1.

(1896) apparition will, it is expected, remove the slight indeterminateness that still exists. It is now known, however, that the former orbit of the comet lay somewhere within the shaded portion of the diagram, between the two large ellipses.

Some months before the comet reached perihelion in 1886, it came into the sphere of *Jupiter's* action, and for more than eight

months remained under its control. When it was near the planet, the Sun's disturbing action was small, and in consequence, the comet's motion for a time was very nearly the same as if it were moving under the influence of *Jupiter's* attraction alone. The orbit which it described about *Jupiter* was an hyperbola having an eccentricity only a little greater than unity. Had its velocity about *Jupiter* been somewhat less, its orbit about the planet would have been an ellipse, and it would then have become a comet-satellite. It happened, however, that its velocity was very little more than was necessary to carry it beyond the planet's predominating influence, and it thus narrowly escaped that fate.

To determine accurately the circumstances of the comet's motion when it was in the immediate neighborhood of *Jupiter* and its orbit previous to that time, requires a very accurate determination of its present orbit as a basis for the computation of the perturbations. Dr. BAUSCHINGER'S definitive elements, which were used by Dr. POOR in his later researches, are very near the truth, as is shown by the close agreement of the present position of the comet with that computed from these elements. For this reason we may accept Dr. POOR'S mean results as substantially correct.

According to his researches the comet passed very close to the planet *Jupiter*, certainly within 158,000 miles of its centre or within 115,000 miles of its surface, and perhaps closer than the Fifth Satellite.

Figure 2 represents the passage of the comet through the planet's satellite system. The satellites all lie nearly in the same plane. Their orbits are represented by the circles I, II, III, IV, V. *Jupiter* is at the center. The comet's orbit was in a plane inclined nearly seventy degrees to that of the satellite system and intersecting it in the line of ☊☊′. The projection of the comet's path on the plane of the satellites' orbits is given, and the actual path being unknown, two curves (hyperbolas) are drawn, between which the true orbit is certainly known to lie. The most probable path of the comet is a curve about midway between the two. Concerning this figure, Dr. POOR says:

"A careful inspection of the figure will show that the comet rose up suddenly from below the satellites' orbits, then passed upwards, and almost directly over *Jupiter*, and then gradually descended, and finally passed below this orbital plane again. As the comet approached *Jupiter*, there could be no close approach

to any of the satellites, excepting at the point where it passed through the plane of their motion. But, on the other hand, as the comet receded from the planet, it hovered over the satellites, and close approaches might occur, provided that the satellites were in the proper places at the right time. A careful investigation of all possible positions of the comet, and of the satellites, showed that a collision was impossible; that the comet did not

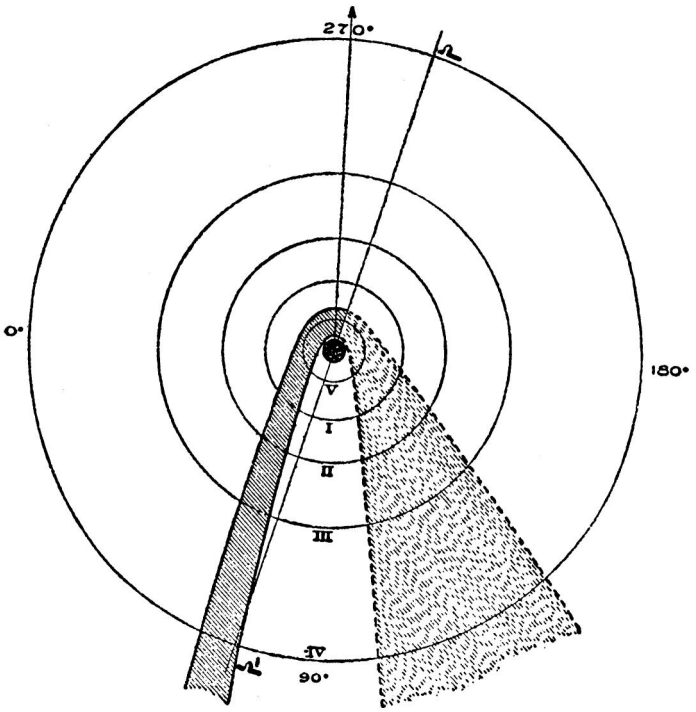

FIG. 2.

even approach near enough to any one of the large satellites to cause the slighest change in the relative motion of the nucleus about *Jupiter*."

According to this result, the observed disruption of the comet could not have been produced by the action of the outer satellite, as seemed probable from the earlier investigation of Dr. CHANDLER. According to Dr. POOR'S work, the mean path of the comet intersected that of the Fifth Satellite, so that direct collision with it was possible. It is impossible to say that a collision did or did not take place, the uncertainties in the motions of the comet, and of the satellite, prevent a definite answer. The ob-

served disruption of the comet may have been caused by this satellite. It is more probable, however, that it was caused by the unequal attractions on the various parts of the comet, due to the great ellipticity of *Jupiter* itself. In this connection, it is of interest to quote the important proposition established by Dr. CHANDLER in his investigation of the orbit of the companion *C* with reference to the principal comet *A*, viz.: "That the force which led to the separation of the components *A* and *C*, whatever its nature, operated in the plane of the comet's orbit, and produced no change in that plane, or in the form of the conic section, but only in its size, and in the direction of its major axis."

Among the interesting questions raised by Dr. CHANDLER'S investigations is that which relates to the past history of this comet and the possibility of its identity with LEXELL'S comet of 1770.

This comet of 1770 was easily visible to the naked eye. It passed within half a million miles of the Earth. Its orbit when computed was found to be one having a period of about five and a half years. At first it seemed strange that a comet so bright should not have been seen before. But in 1767 it passed so close to *Jupiter* that its orbit was completely changed. Previous to that time it had been moving in a larger orbit with a perihelion distance so great (nearly the same as *Jupiter*), that it could not be seen from the Earth. In 1779 it approached very much closer to *Jupiter* than in 1767, and its orbit was again entirely changed, being again thrown into a larger ellipse with a greater perihelion distance. Since 1770 this comet has not been seen, and on this account it is commonly known as "The Lost Comet."

According to Dr. CHANDLER'S investigations it seemed for a time highly probable that the comet 1889 V was the fourth return of the celebrated LEXELL'S comet. Dr. POOR'S later work renders this quite doubtful. He says: "Between these two appulses, 1779 and 1886, there intervened a period of one hundred and seven years, which must be accurately accounted for in order to establish the identify of these two remarkable bodies. But assuming the substantial correctness of the present investigation, we cannot directly account for these necessary years. For the period of Comet V in 1884, or previous to its disturbance, has been shown to be 31.38 ± 1.50 years, which is not an aliquot part of 107. Hence, unless in the intervening years, the comet suffered other and marked disturbances in its orbit, the entire

question as to the identity between the two bodies falls at once. A further investigation shows us that such disturbances did take place, but leaves us utterly in the dark as to the resulting changes in the orbit. The uncertainty in the original observations become so magnified in this part of the comet's orbit, that we can no longer trace its path with absolute accuracy, we cannot say with certainty that the two comets are or are not identical. The probability seems to be that they are not one and the same body."

The observations of this year, 1896, will, it is expected, furnish the data by means of which it will be possible to remove the uncertainties that have existed concerning the present orbit of the comet. When this orbit is known with entire certainty, the circumstances of its passage through *Jupiter's* satellite system in 1886 and its history previous to that time, will become much more determinate.

The comet will not again approach close to *Jupiter* until 1922. It will then experience great perturbations and the elements of its orbit will be changed very considerably, but not at all to the extent they were in 1886.

MOUNT HAMILTON, Cal., July 22, 1896.